Numerical studies to investigate the effect of inclusion-matrix debonding on subsurface crack initiation due to rolling contact fatigue in bearings

Gopalakrishnan Ravi [1,2*], Ksenija Nikolic[2,3], Roumen Petrov[3], Kim Verbeken[4], Wim De Waele [1], Stijn Hertelé [1]

[1] *Department EMSME, Soete Laboratory , Ghent University, Belgium*

[2] *SIM vzw, Technologiepark 48, 9052 Zwijnaarde, Belgium*

[3] *Department EMSME ,Materials science and technology group, Ghent University, Belgium*

[4] *Dept. MaTCh, Research group Sustainable Materials Science, Ghent University, Belgium*

**Corresponding author: Gopalakrishnan.ravi@ugent.be & +32465780706.*

Abstract. Offshore wind turbine bearings operate in harsh working conditions and may fail prematurely due to rolling contact fatigue (RCF). The microstructural changes associated with RCF are often reported as *(i)* butterfly wing formation around non-metallic inclusions, *(ii)* dark etching areas, and *(iii)* white etching cracking (WEC). Understanding these premature failures requires the study of RCF at multiple scales (macro-and microscopic) and stages (crack initiation and propagation). As the fatigue crack initiation begins at both, bonded and debonded inclusions, not many numerical studies have been reported that investigate the effect of inclusion debonding on crack initiation in bearings and its lifetime. This work starts with analysing the characteristics of inclusions in bearings that were sliced for microscopic analysis. Next, it presents a 2D finite element (FE) modelling approach to calculate and compare a fatigue indication parameter for both intact and partially debonded inclusions in bearings. The global FE model simulates parts of the contact bodies such as roller and raceway to represent the contact zone. A submodel containing an inclusion is derived from the global FE model of rolling contact. Moving Hertzian load is simulated to mimic the rolling pass and the stress history around the inclusion/matrix interface is adopted within a multi-axial critical plane approach to calculate fatigue damage. This study also investigates the stress state around an inclusion due to the combined effect of normal load and surface traction between the roller and inner raceway. This gives us an insight into the underlying physics behind the mechanism of subsurface initiated RCF. Investigation of the link between RCF and white etching cracks is ongoing.

Keywords: Rolling contact fatigue, Debonding, RCF crack initiation, RCF damage, Critical plane approach

Acknowledgements: The authors gratefully acknowledge the financial support via the MaDurOS program from VLAIO (Flemish Agency for Innovation and Entrepreneurship) and SIM (Stratigic Initiative Materials) through project SBO MaSiWEC (HBC.2017.0606).